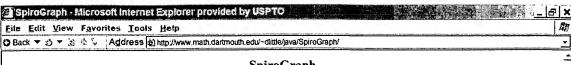


Claims 1 and 6



The path of a point fixed relative to a circle that rolls along a straight line is called a prochood. The easiest way to visualize this phenomenon is to think of the path of a reflector on a bicycle as someone is closing on a level street. The reflector rotates around the bub of the wheel, but yet the bub of the wheel is moving relative to the ground. Here is an apply that demonstrates this (without the bicycle) (NOTE: As of 10-500, I have rewritten the cycloid applet. I had received some comments suggesting that the old version caused some computers to crash. Hopefully the problem has been fixed. Let me know if you experience any further problems

Now think about what happens if the circle is instead rotating around another circle. In other words, the cyclist is now pedaling his ber way around the equator, instead of down the street. Mathematicians call this path an epicycloid. The rest of the world calls them SpiroGrapho!! The parametric equations for these curves are given by:

x(t)*(R+r)cos(t) - p*cos((R+r)t/r) y(t)*(R+r)cos(t) - p*sin((R+r)t/r)

where R., and p are defined below. The applet below allows you to create all the SpinoGraphs your heart dexires by varying the values of R, a and p, as well as the following parameters:

- Radius I (R)
 Radius of circle (equator) centered at the origin.
- Radius of circle (bicycle wheel) centered at (R+r,0)

- Position (p)
 Distance of Point (reflector) from the center of Circle2, the circle of radius s.

- Distance of Point (reflector) from the center of Circle 2, the circle of statius z.

 Velocity
 Speed at which the SpiroGraph is drawn, with 0 being the slowest and 10 being the fastest. Can be adjusted while drawing is taking place. Sometimes half the fun is seeing your SpiroGraph being drawn! Sometimes not!

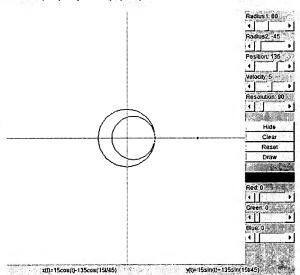
 Resolution
 Controls how precise the SpiroGraph is drawn. For instance, with a Resolution of 360, the points (a(t), y(t)) are plotted for t=0, 1, 2, 3, 4, 5, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 8, 10, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 8, 10, ..., 359, 360 are used. Be careful, the larger the Resolution, the longer it will take to draw the SpiroGraph. Normally, a value between 170 and 360 will be good enough. With a small value of Radius 2 (say Radius 2=1), a small change in Resolution can result in remarkably different SpiroGraphs.

 Hild:/Show
 Changing the value of this button will determine whether or not to display the circles/saces while drawing is taking place. Note: SpiroGraphs are drawn much faster if you "Hide" the circles/saces.
- Clear
 This button will clear the screen of all SpiroGraphs.

- Reset
 This button stops the current SpiroGraph and returns Circle? and the Point to its original position

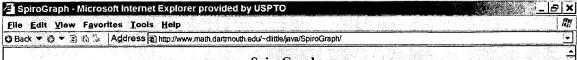
- These buttons should be self explanatory.

 Red/Green/Blue You can adjust the values of these sliders to draw your SpiroGraph in virtually any color you like!



SIMPLE	Radiusl	Radius2	Postion	Resolution	Try this:
Cardioid	60	60	60		See what happens when you vary the postion to the left or to the right. How could you get a cardioid oriented differently?
Astroid	. 60	-13	-15	270	Another name for an astroid is a hypocycloid of four cusps. What would you change to get the same picture cotated 45 degrees? Vary the radius and try to get 3,5 or 6 cusps. Also, vary the position and see what happens.
Four-leaved rose	60	-15	45	270	Try to vary the radius and postion to get 3,5 or 6 leaves
Vertical Line	60	.30	.30	270	What would you change to get a honzomal line?
Ellipse	50	-30	-90	270	What would you have to change in order to get an ellipse oriented horizontally? How would you get an ellipse on the inside of the fixed circle?
Rounded Square	50	-45	-101	270	How about a rounded mangle or pentagon?
Gold fish	75	-25	85	270	This is supposed to be fun, right?

-



The path of a point fixed relative to a circle that rolls along a straight line is called a rockold. The easiest way to visualize this phenomenon is to think of the path of a reflector on a bicycle as someone is riding on a level street. The reflector rotates around the hab of the wheel but yet the hab of the wheel is moving relative to the ground. Here is an applic that demonstrates this (without the bicycle) (NOTE: As of 10/6/00,1 have rewritten the cycloid applet. I had received some comments suggesting that the old version caused some computers to crash. Hopefully the problem has been fixed. Let me know if you experience any further problems.

Now think about what happens if the circle is instead rotating around another circle. In other words, the cyclist is now pedaling his her way around the equator, instead of down the street. Mathematicians call this path an epitycloid. The rest of the world calls them SpireGrapher! The parametric equations for these curves are given by:

#(t)=(R+r)cos(t) - p*cos((R+r)t/r) Y(t)=(R+r)tin(t) - p*sin((R+r)t/r)

where R.f., and p are defined below. The applet below allows you to create all the SpiroGraphs your heart desires by varying the values of R. c and p, as well as the following parameters:

- Radius 1 (R)
 Radius of circle (equator) centered at the origin.
 Radius 2 (r)
 Radius 0 (circle (bicycle wheel) centered at (R=r,0)

octiv
Speed at which the SpiroGraph is drawn, with 0 being the slowest and 10 being the fastest. Can be adjusted while drawing is taking place. Sometimes half the fun is seeing your SpiroGraph being
drawn! Sometimes not!

· Resolution

Resolution
Controls how precise the SpiroGraph is drawn. For instance, with a Resolution of 360, the points (a(t), y(t)) are plotted for t=0, 1, 2, 3, 4, 5, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 3, 10, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 3, 10, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 3, 10, ..., 359, 360 degrees. With a Resolution of 180, only the value to draw the SpiroGraph. Normally, a value between 120 and 360 will be good enough. With a small value of Radius 2 (say Radius 2-1), a small change in Resolution can result in remarkably different SpiroGraphs.

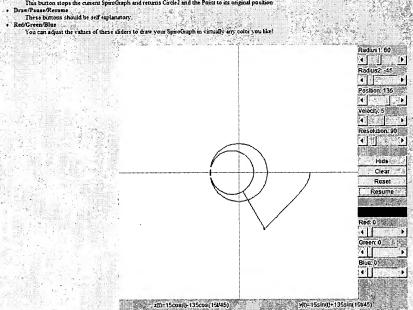
Hido-Show
Changing the value of this button will determine whether or not to display the circles/axes while drawing is taking place. Nete: SpiroGraphs are drawn much faster if you "Hide" the circles/axes.

- Clear
 This button will clear the screen of all SpiroGraphs.

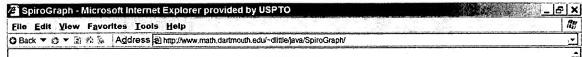
- This button was created and a second spirit of the Point to its original position.

 Reset

 This button stops the current SpirioGraph and returns Circle? and the Point to its original position.



SIMPLE	Radius 1	Radnus2	Position	Resolution	Try this:
Cardioid	60	60	60	270	See what happens when you vary the postion to the left or to the right. How could you get a cardioid oriented differently?
Astroid	60	-13	-15	270	Another name for an astroid is a hypocycloid of four cusps. What would you change to get the same picture rotated 45 degrees? Very the radius and try to get 3,5 or 6 cusps. Also, vary the position and see what happens.
Four-leaved	60	-15	45	270	Try to vary the radius and postion to get 3,5 or 6 leaves
Vertical Line	60	-30	-33	270	What would you change to get a horizontal line?
Ellipse	60	-30	-90	270	What would you have to change in order to get an ellipse onented horizontally? How would you get an ellipse on the inside of the fixed circle?
Rounded Square	60	-45	-101	279	How about a counded triangle or pentagon?
Gold fish	74	-25	25	273	This is supposed to be fun, right?



The path of a point fixed relative to a circle that rolls along a straight line is called a prochold. The easiest way to visualize this phenomenon is to drink of the path of a reflector on a bicycle as someone is dding on a level street. The reflector rotates around the hub of the wheel, but yet the hub of the wheel is moving relative to the ground. Here is an <u>applet</u> that demonstrates this (without the bicycle) (NOTE: As of 10/5 00, I have rewritten the cycloid applet. I had received some comments suggesting that the old version caused some computers to crash. Hopefully the problem has been fixed. Let me know if you experience any further problems.)

Now think about what happens if the circle is instead rotating around another circle. In other words, the cyclist is now pedating his her way around the equator, instead of down the street. Mathematicians call this path an epicycloid. The rest of the world calls them SpiroGraphs!! The parametric equations for these curves are given by:

u(t)=(R+r)cos(t) - p*cos((R+r)t/r) y(t)=(R+r)rin(t) - p*sin((R+r)t/r)

where R.r. and p are defined below. The applet below allows you to create all the SpiroGraphs your heart desires by varying the values of R. 1 and p, as well as the following purameters:

- Radius I (R)
 Radius of circle (equator) centered at the origin.

- Radius of circle (equator) centered at the origin.

 Radius of circle (equator) centered at (R-1,0)

 Radius of circle (bicycle wheel) centered at (R-1,0)

 Position (p)

 Distance of Point (reflector) from the center of Circle 2, the circle of radius r.

Distance of Point (reflector) from the center of Circle 2, the circle of radius r.

Velocity

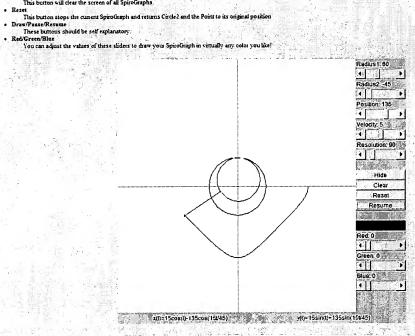
Speed at which the Spiro(rasph is drawn, with 0 being the stowest and 10 being the fastest. Can be adjusted while drawing is taking place. Sometimes half the fun is seeing your Spiro(rasph being drawn! Sometimes not!

Resolution

Controls how precise the Spiro(rasph is drawn. For instance, with a Resolution of 360, the points (x(t), y(t)) are plotted for t=0, 1, 2, 3, 4, 5, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 3, 10, ..., 355, 360 are used. Be careful, the larger the Resolution, the longer is will take to draw the Spiro(rasph. Normally, a value between 270 and 360 will be good enough. With a small value of Radius? (say Radius?=1), a small change in Resolution can result in remarkably different Spiro(rasph.)

Changes the value of this button will determine a temper or not to display the circles/axes while drawns is taking place. Nets: Spiro(rasphs are drawn much faster if you "Eide" the circles/axes.

- Changing the value of this button will determine whether or not to display the circles ares while drawing is taking place. Note: SpiroGraphs are drawn much faster if you "Fide" the circles ares.
- Clear
 This button will clear the screen of all SpiroGraphs.



~ SIMPLE CURVES	Radius1	Radius2	Position	Resolution	Try this:
Cardioid	60	60	60	270	See what happens when you vary the postion to the left or to the night. How could you get a cardioid oriented differently?
Astroid	60	-15	-15	270	Another name for an astroid is a hypocycloid of four cusps. What would you change to get the same picture rotated 45 degrees? Vary the radius and try to get 3,5 or 6 cusps. Also, vary the position and see what happens.
Four-leaved rose	60	-15	45	270	Try to vary the radius and postion to get 3,5 or 6 leaves
Vertical Line	60	-30	-30	270	What would you change to get a horizontal line?
Ellipse	50	-30	-90	270	What would you have to change in order to get an ellipse oriented horizontally? How would you get an ellipse on the inside of the fixed circle?
Rounded Square	60	-45	-101	279	How about a rounded triangle or pentagon?
Gold fish	75	~25	85	270	This is supposed to be fun, right?

SpiroGraph - Microsoft Internet Explorer provided by USPTO Ry File Edit Yiew Favorites Iools Help O Back ▼ O ▼ ② 6 🖟 Address ② http://www.math.dartmouth.edu/~dlittle/java/SpiroGraph/ · 1

SpiroGraph

The path of a point fixed relative to a circle that rolls along a straight line is called a prochoid. The easiest way to visualize this phenomenon is to think of the path of a reflector on a bicycle as someone is riding on a level street. The reflector rotates around the hub of the wheel, but yet the hub of the wheel is moving relative to the ground. Here is an applet that demonstrates this (without the bicycle) (NOTE: As of 10-500, I have rewritten the cycloid applet. I had received some comments suggesting that the old version caused some computers to crash. Hopefully the problem has been fixed. Let me know if you experience any further problems.)

Now think about what happens if the circle is instead rotating around another circle. In other words, the cyclist is now pedaling his ber way around the equator, instead of down the street. Mathematicians call this path an epitycloid. The rest of the world calls them SpiroGraphall The parametric equations for these curves are given by:

$$\begin{split} \mathbf{z}(t) &= (R+r)\cos(t) - p^2\cos\left((R+r)t/r\right) \\ \mathbf{y}(t) &= (R+r)\sin(t) - p^2\sin\left((R+r)t/r\right) \end{split}$$

where R.r. and pure defined below. The applet below allows you to create all the SpiroGraphs your heart desires by varying the values of R, a and p, as well as the following purameters:

- Radius I (R)
 Radius of circle (equator) centered at the origin.

- Radius of circle (equator) centered at the origin.

 Radius of circle (equator) centered at (R-r_i,0)

 Pastition (p)

 Distance of Point (reflector) from the center of Circle2, the circle of sadius r.

 Velocity

 Speed at which the SpiroGraph is drawn, with 0 being the slowest and 10 being the fastest. Can be adjusted while drawing is taking place. Sometimes half the fun is seeing your SpiroGraph being drawn! Sometimes not!

 Resolution

 Controls how precise the SpiroGraph is drawn. For instance, with a Resolution of 360, the points (x(t), y(t)) are plotted for t=0, 1, 2, 3, 4, 5, ..., 359, 360 degrees. With a Resolution of 180, only the values of c=0, 2, 4, 6, 8, 1, 0, ..., 359, 360 are used. Be careful, the larger the Resolution, the longer it will take to draw the SpiroGraph Normally, a value between 270 and 360 will be good enough. With a small value of Radius 2 (say Radius 2=1), a small change in Resolution can result in remarkably different SpiroGraph.

 Hide-Show

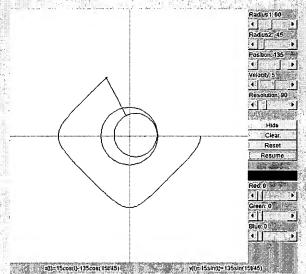
 Changing the value of this button will determine whether or not to display the circles (ases while drawing is taking place. Nete: SpiroGraphs are drawn much faster if you "Hide" the circles/sace.

 Clear ...
- Clear.
 This button will clear the screen of all SpiroGraphs.

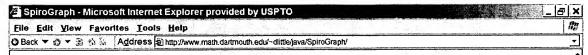
- Reset
 This button stops the current SpiroGraph and returns Circle? and the Point to its original position This button stops the current opmounage was account.

 Draw/Pause/Resume
 These buttons should be self explanatory.

 Red/Green/Blue
 You can adjust the values of these sliders to draw your SpiroGraph in virtually any color you like!



SIMPLE CURVES	Radius	Radius2	Position	Resolution	Try this:
Cardioid	60	60	60	270	See what happens when you vary the postion to the left or to the right. How could you get a cardioid oriented differently?
Astroid	60	-15	-15	270	Another name for an astroid is a hypocycloid of four cusps. What would you change to get the same picture rotated 45 degrees? Vary the radius and try to get 3,5 or 6 cusps. Also, vary the position and see what happens.
Four-leaved rose	60	-15	45	270	Try to vary the radius and postion to get 3,5 or 6 leaves
Vertical Line	60	-30	-30	270	What would you change to get a horizontal line?
Ellipse	50	-30	-90	270	What would you have to change in order to get in ellipse oriented horizontally? How would you get an ellipse on the inside of the fixed circle?
Rounded Square	60	-45	-101	270	How about a rounded triangle or pentagon?
Gold fish	75	~25	\$5	270	This is supposed to be fun, right?



The path of a point fixed relative to a circle that rolls along a straight line is called a rockord. The easiest way to visualize this phenomenon is to think of the path of a reflector on a bicycle as someone is riding on a level street. The reflector rotates around the hab of the wheel, but yet the hab of the wheel is moving relative to the ground. Here is an applet that demonstrates this (without the bicycle) (NOTE: As of 10 & 00, I have rewritten the cycloid applet. I had received some comments suggesting that the old version caused some computers to crash. Hopefully the problem has been fixed. Let me know if you experience any further problems.)

Now think about what happens if the circle is instead rotating around another circle. In other words, the cyclist is now pedating his her way around the equator, instead of down the street. Mathematicians call this path an epitycloid. The rest of the world calls them SpiroGraphs!! The parametric equations for these curves are given by:

x(t)=(R+r)crs(t) - p+ccs((R+r)t/r) y(t)=(R+r)sin(t) - p+sin((R+r)t/r)

where R., and p are defined below. The applet below allows you to create all the SpiroGraphs your heart desires by varying the values of R. and p, as well as the following parameters:

- Radius 1 (R)
 Radius of circle (equator) centered at the origin.
 Radius 2 (r)
 Radius 2 (r)
 Radius 2 (R=r,0)
- Position (p)
 Distance of Point (reflector) from the center of Circle 2, the circle of radius r.
- Distance of rout greaterory from the season of control of the state of
- drawn! Sometimes not:

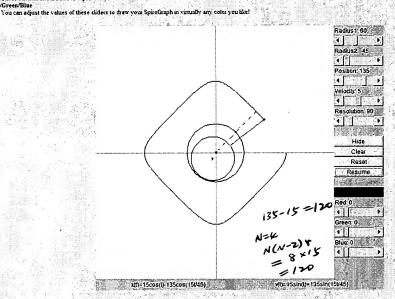
 Resultation
 Controls how precise the SpiroGraph is drawn. For instance, with a Resolution of 360, the points [a(t), y(t)) are plotted for t=0, 1, 2, 3, 4, 5, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 8, 10, ..., 359, 360 are used. Be cueful, the larger the Resolution, the longer it will take to draw the SpiroGraph. Normally, a value between 270 and 360 will be good enough. With a small value of Radius 2 (say Radius 2-1), a small change in Resolution can result in remarkably different SpiroGraphs.

 Hides/Show
- Changing the value of this button will determine whether or not to display the circles uses while drawing it taking place. Note: SpiroGraphs are drawn much faster if you "Fide" the circles uses. Clear
 This button will clear the screen of all SpiroGraphs.

- This button was creat use access to an appropriate This button stops the current SpiroGraph and returns Cricle? and the Point to its original position DrawPasserReturns
 These buttons should be self explanatory.

 RedGreen/Blue

 RedGreen/Blue



SIMPLE - CURVES	Radius l	Radius2	Position	Resolution	Try this:
Cardioid	50	60	60		See what happens when you vary the postion to the left or to the right. How could you get a cardioid oriented differently?
Astroid	60	-15	-15	270	Another name for an astroid is a hypocycloid of four cusps. What would you change to get the same picture rotated 45 degrees? Vary the radius and thy to get 3,5 or 6 cusps. Also vary the position and see what happens.
Four-leaved rose	60	-15	45	270	Try to vary the radius and postion to get 3,5 or 6 leaves
Vertical Line	j 60	-30	-30	270	What would you change to get a horizontal line?
Ellipse	80	-30	-90	270	What would you have to change in order to get an ellipse oriented horizontally? How would you get an ellipse on the inside of the fixed circle?
Rounded Square	60	-45	-191	270	How about a counded triangle or pentagon?
Gold fish	75	-25	85	270	This is supposed to be fun, right?

The path of a point fixed relative to a circle that rolls along a straight line is called a prochold. The easiest way to visualize this phenomenon is to think of the path of a cellector on a bicycle as someone is infing on a level street. The reflector cotates around the hab of the wheel, but yet the hab of the wheel is moving relative to the ground. Here is an applet that demonstrates this (without the bicycle) (NOTE: As of 10% 00, I have rewritten the cycloid applet. I had received some comments suggesting that the old version caused some computers to trash. Ropefully the problem has been fixed. Let me know if you experience any further problems.)

Now think about what happens if the circle is instead totaling around another circle. In other words, the cyclist is now pedaling his her way around the equator, instead of down the street. Mathematicians call this path an aprity-cloid. The test of the world calls them SpiroGrapha!! The parametric equations for these curves are given by:

$$\begin{split} \mathbf{z}(t) &= (\mathbf{R} + \mathbf{r}) \cos(t) - \mathbf{p}^* \cos((\mathbf{R} + \mathbf{r}) \mathbf{t} / \mathbf{r}) \\ \mathbf{y}(t) &= (\mathbf{R} + \mathbf{r}) \sin(t) - \mathbf{p}^* \sin((\mathbf{R} + \mathbf{r}) \mathbf{t} / \mathbf{r}) \end{split}$$

where Rs., and pure defined below. The applet below allows you to create all the SpinoGraphs your heart dezires by varying the values of R, 1 and p, as well as the following parameters:

- · Radius l (R)

- Radius of circle (equator) centered at the origin.

 Radius 2 (r)

 Radius of circle (bicycle wheel) centered at (R+t,0)
- Position (p)
 Distance of Point (reflector) from the center of Circle2, the circle of radius s.

Distance of Point (reflector) from the center of Circle2, the circle of radius s.

Velocity
Speed at which the SpiroGraph is drawn, with 0 being the slowest and 10 being the fastest. Can be adjusted while drawing is taking place. Sometimes half the fun is seeing your SpiroGraph being drawn! Sometimes not!

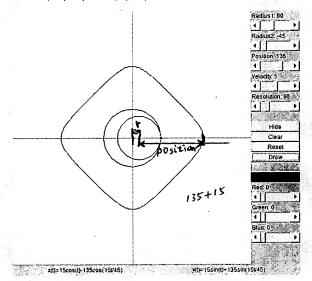
Resilution
Controls how precise the SpiroGraph is drawn. For instance, with a Resolution of 560, the points (a (1), y(1)) are plotted for t=0, 1, 2, 3, 4, 5, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 8, 10, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 8, 10, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 8, 10, ..., 359, 360 degrees. With a Resolution of 180, only the values of t=0, 2, 4, 6, 8, 10, ..., 359, 360 degrees. With a Resolution of 180, only the values of two the small value of Radius 2 (say Radius 2=1), a small change in Resolution can result in remarkably different SpiroGraphs.

Hide-Show
Changing the value of this button will determine whether or not to display the circles/axes while drawing is taking place. Note: SpiroGraphs are drawn much faster if you "Hide" the circles/axes.

Clear

- Clear
 This button will clear the screen of all SpiroGraphs.
- This button stops the current SpiroGraph and returns Circle2 and the Point to its original position
- These buttons should be self explanatory.
- . Red/Green/Blue

You can adjust the values of these sliders to thaw your SpitoGraph in virtually any color you like!



CURVES		Radius2	Position	Resolution	Try this:
Cardioid	60	60	60	270	See what happens when you vary the postion to the left or to the right. How could you get a cardioid oriented differently?
Astroid	60	-15	-15		Another name for an astroid is a hypotycloid of four cusps What would you change to get the same picture rotated 45 degrees? Very the radius and try to get 3,5 or 6 cusps. Also vary the position and see what happens.
Four-leaved rose	50	-15	45	270	Try to vary the radius and postion to get 3,5 or 6 leaves
Ventical Line	60	-30	-30	270	What would you change to get a horizontal line?
Ellipse	50	-30	-90		What would you have to change in order to get an ellipse oriented horizontally? How would you get an ellipse on the inside of the fixed circle?
Rounded Square	60	-45	-101	270	How about a rounded triangle or pentagon?
Gold fish	75	-25	85	270	This is supposed to be fun, right?